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Digital Solutions for a Climate Neutral Economy: International Framework of Eco-Digital Projects

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The research reveals practical side of a twin green and digital transition in terms of a global path to climate neutral economy. Digitalization is considered as a driving force behind the transition towards a low-carbon economy. The article focuses on wide international experience of IT implementation for industrial decarbonization. Analytical database of the research covers more than 200 different eco-digital projects in various areas of climate regulations given by international organizations. This allows to outline international framework of eco-digital projects based on geolocation, regional features, IT decisions, level of technological support and climate influence. International differentiation of climate-digital projects was established by region. Comprehensive analysis of these data is provided to identify the gap in digital capabilities and climate targets. The rating of IT applied in climate-digital projects was built. As a result, the research proposes key project ways of the twin green and digital transition that are the most attractive for achieving climate neutrality on a global scale.

Climate neutrality, green economy, eco-digital, twin transition.

I. Introduction

Climate neutrality has become a major challenge for global society on its vital path to the greener future. This case poses the greatest difficulties for the modern economy since decarbonization implies complex transformation of global manufacturing processes, consumption chains and entrepreneurial behavior patterns. Despite the fact, that international actors are more likely to engage in lobal climate initiatives such as Paris Agreement, Green Deal, European roadmap 2050, Fit for 55 and others, the pace of change remains insufficient to achieve “zero” emissions and prevent irreversible climate change [1]. Moreover, the mentioned year 2050 was not chosen by chance as a year of achieving climate neutrality of the economy. Delaying this countdown may lead to the irreversibile climate change and global struggle for natural resources [2], [3].

With this in mind, digitalization could be considered as a driving force for the climate neutrality, enabling a wide range of digital tools and applications in climate governance and regulations.

Furthermore, European Commission declares the necessity of namely “twin green and digital transition” of the economy [4]. Modern scientists maintain the idea of synergetic linkages in “eco-digital” space [5], [6], [7], [8] and emphasize fundamental role of technology clusters in climate stability, particularly in metallurgy, agriculture, energy consumption and transportation [9], [10], [11], [12]. We also have to admit such remarkable global initiatives as “Climate Neutral Now” by United Nations, “Sustainability in the Digital Age” by Future Earth Canada Hub, “Breakthrough energy” by Bill Hates and “Sustainable digitalization” by European Digital SME Alliance. These platforms collect data about eco-digital projects and make first attempts to arrange them according to the climate neutrality targets.

However, the scientific discourse lacks consistency in the presentation of the global digital paradigm of the green transition. Besides, there is still insufficient understanding of the digital impact on climate results caused by different industries and world regions. Technological differentiation of eco-digital projects also deserves additional attention. The outlined issues formed the basis of our research.

II. Materials and methods

The research provided complex assessment of international framework of climate-digital projects aimed at the climate neutrality. Quantitative analysis was built on the basis of comprehensive open data provided by Future

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Earth Canada Hub on the web platform "Sustainability in the Digital Age" [13]. This data was chosen as a major statistical material because of 3 main reasons. First, this database provides relevant information for more than 225 climate-digital projects, collected worldwide. Second, this database was arranged on clear principles and methodology. Thus, it includes only those eco-digital projects, that help to reduce the sources or increase the sinks of GHG; leverage digital tools; influence or/and inform governmental and non-governmental players. Third, all information is presented in the original tabular form without distortion. This allows each researcher to build their own models and assumptions, define labels, logical markers and criteria.

Thus, the data was sampled, filtered and ranked with the diversification of the following categories and subcategories: region of the project; form of leading (academic institution; civil society; partnership; private sector); applied digital decisions; strategy and focus of the project.

We also used metodological approach given in the analytical report [14] and expanded the study of digital tools in climate projects. At the next stage of the research, key elements of abstract and logical, systematisation and generalisation methods were applied to rethink systemic linkage between digital and green transition.

III. Results and Discussion

The implementation of digital technologies may effectively address ecological concerns, caused by modern manufacturing. Moreover, there are at least three areas in which digitalization can contribute to environmental sustainability.

The first area focuses on reducing greenhouse gas emissions throughout digitalisation and optimization of production processes, resource consumption and transportation logistics.

The second area involves eco-innovations to absorb harmful substances in urban environments and mitigate the impact of the greenhouse effect.

Finally, the third area implies regulating framework for climate neutrality within the creation of digital platforms for monitoring and controlling environmental impacts, both positive and negative, while also engaging stakeholders in this process.

International experience of climate-digital projects allows to assume the following effective digital initiatives aimed at climate neutrality and stability [8], [15], [16]:

– web platforms with open access to data in all areas related to the use of natural resources, subsoil and environmental impacts of production;

– digital registers that continuously update the country's natural wealth and track changes caused by GHG emissions;

– digital maps that integrate geo-data for effective resource management;

– digital "investment atlases" and digital auctions providing transparent sale of natural resources for various industries;

– integrated system of digital permits. On the hand, it provides clear subsoil use enabling to streamline the process and create a transparent register of subsoil management. On the other hand, it also includes wide range of "digital tickets" for individuals as permitions for hunting, fishing, logging, etc.;

– digital monitoring systems that track emissions in both industrial zones and public sector, with generating automatic protocols for environmental violations.

However, the demand for climate programs differs significantly depending on the region, as well as the possibility for their implementation. Based on the analysis of statistical data [13], the following international differentiation was established (Fig.1).

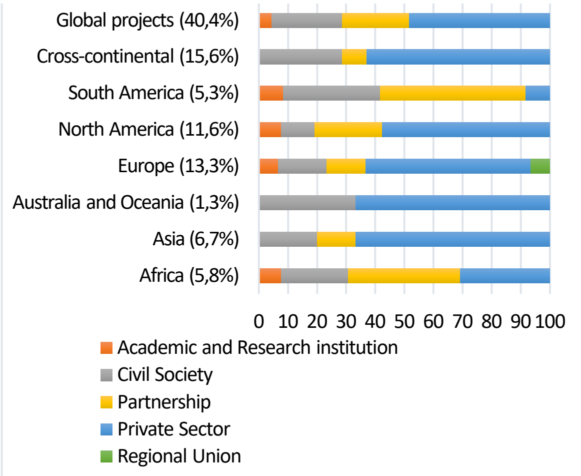

Fig. 1. International diferenciation of climate-digital projects by region.

The diagram represents, that lion's share of the climate-digital initiatives regards to global projects and cross-continental initiatives, that are highly versatile in use worldwide. In addition, most of them are provided by private sector (48%), civil society (24%) and in partnership and consortium (23%). We have to admit infinitesimal share of academic institutions involved in climate-digital project management (4%), although they will have to develop global paradigm of green-digital transition.

A large amount of climate-digital projects concern ecological issues in Europe (13,3%) and North America (11,6%), while African, Asian and South American decarbonization path is still under-served. Low indicator of project activities in Australia may be derived from the fact that Australia rather joins global and cross-continental eco-digital initiatives.

Another remarkable fact is that the most effective model for twin green and digital transition in "ecologically deprived" regions as Africa and South America led to partnership and civil society. Thus, voice of the society will play crucial role in fighting climate change in the nearest future. Analysis confirmed the global willingness to support third-world countries in their path to climate neutrality. Over 30 cross-continental projects (15,5 %) are elaborated by the institutions of EU and USA directly for Africa, Asia and South America [14].

Considering the strategies for climate-digital management, we pay attention to the Philanthropy's model, that outlines 4 appropriate levels of green governance [17]:

1. Data mobilization to strengthen decision-making (S1).
2. Digital optimization of existing strategies (S2).
3. Modeling behavioral change (S3).
4. Participation and empowerment (S4).

Systematization of existing database of 225 projects by this criteria allows to represent the following space model (Fig. 2).

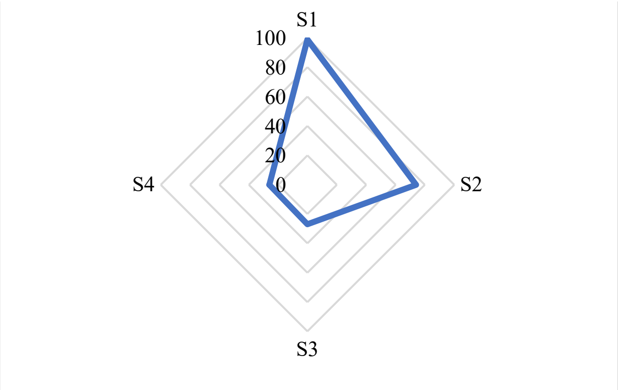

Fig. 2. Space model of strategical priorities of climate-digital projects.

The diagram depicts apparent focusing on data mobilization and digital optimization of existing strategies. Despite the fact, that such tendency contributes to industrial adaptation and likely strengthen decision-making process, this is not enough for qualitative changes and achieving the climate neutrality in the nearest future. There are only a few project initiatives about participation and empowerment of the society. Meanwhile, climate neutrality implies profound and systemic behavioral change of economic actors.

Thinking this way, we assume a possibility to engage more academic and research institutions, international organizations, and unions to refocus climate-digital projects into the spheres of behavior change and empowerment.

The majority of contemporary databases containing information on climate-digital projects concentrate on several key areas. These include the expansion of carbon offsetting, carbon credit, and other environmental commodity markets. Additionally, there is a focus on biodiversity and ecosystem conservation, as well as the involvement of local communities. There is also an emphasis on promoting food and water security through sustainable agriculture practices, as well as improving air quality. The adoption of renewable energy sources is also a key area of interest. Other notable focuses include supporting various environmental policies, strengthening private sector sustainability accounting and reporting, and reducing emissions by improving efficiency and optimizing energy use.

No doubt, overall effectiveness of climate-digital initiatives results not only from the institutional ability, but directly from the technological level and access to innovation. Digitalization provides a wide range of IT decisions for the economy. Some of them are successfully applied in climate governance (Fig. 3)

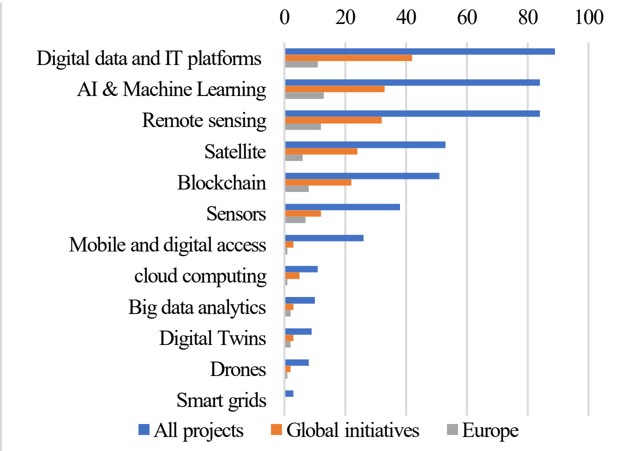

Fig. 3. Rating of IT applied in clamate-digital projects.

As we can see, the most popular technological decisions for climate regulation include digital data and IT platforms, artificial intelligence, machine learning, remote sensing, satellites and blockchain, while digital twins, drones and smart grids are used in separate projects.

Moreover, the quantitative analysis of applied IT showed its significant differentiation depending on the project scale (Table 1).

TABLE 1 FRIEQUENCY OF IT USE IN CLIMATE-DIGITAL PROJECTS (BY EACH 100 PROJECTS)

Number of IT applied in the project	**1**	**2**	**3 and more**
IT, that could be used individually or in groups			
Digital data and collaborative platforms	38	47	36
AI & Machine Learning	22	33	63
Blockchain	27	24	15
Mobile and digital access	10	14	13
cloud computing	1	0	14
Digital Twins	1	8	6
Smart grids	2	0	1
IT, that could be used directly in groups			
Satellite	0	27	56
Sensors	0	6	49
Big data analytics	0	2	13
Drones	0	2	10
Remote sensing	0	37	92

The table above reveals that the most important technologies for modern climate neutral targets are collaborative IT platforms, AI and Machine learning, and blockchain. These digital decisions are widely applied in climate digital projects individually or in groups with other technologies. In contrary, satellites, sensors, drones and remote sensing need additional support and are used in groups with another IT. Such differentiation reflects current demand of the climate neutral economy and its overall orientation on adaptive strategies (S1, S2 at Fig. 2).

In general, international framework of climate-digital projects contributes to overcoming regional barriers on the way to global neutrality of the economy. We came to the conclusion about the most important ways of the "green-digital" development:

1. Monitoring systems and data analysis of climate change. It implies wide application of sensors, drones, satellite technologies for in-depth analysis of climate changes and emissions in the context of the activities of individual industries and world regions.

2. "Big data" as a tool for assessing the current state of climate change and forecasting its consequences.

3. Launching the information platforms and international R&D clusters for the direct development and implementation of innovative technologies in the field of energy efficiency, renewable energy and other areas related to the reduction of GHG emissions.

4. Integration of the digital tools into the climate diplomacy and green communications all over the world. In particular, the development of web portals, mobile applications, social networks and educational materials to involve the society, business and government in the decision-making process in order to increase their awareness about opportunities, directions and sources of green transformation projects.

5. Development of digital educational platforms and joint scientific programs in the field of climate management aimed at the overcoming the gap in resource provision of projects and formation of ecological thinking.

Thinking this way, digitalization could be considered as follows.

First, digitalization as a set of applied digital tools and technologies to ensure climate neutrality at the level of individual industries and institutions.

Second, digitalization, as a process of optimization of green transition processes, integration of technologies into the production cycle with the aim of increasing its environmental friendliness, productivity and energy efficiency.

Third, digitization as a dimension of the global information environment, which covers a wide range of stakeholders: the public, authorities, business, specialized experts, scientists, educators for the joint development and formation of climate policy instruments, which will ensure a wider understanding and support of climate-oriented programs by all players of the international economic space.

IV. Conclusions

Modern international framework of climate-digital projects covers a wide range of digital decisions on the global way to a climate neutrality.

The demand for climate programs varies significantly depending on the region and the feasibility of implementation. The majority of climate-digital initiatives are focused on global projects and cross-continental initiatives that are highly versatile and applicable worldwide. These initiatives are predominantly provided by the private sector, civil society, and through partnerships and consortia.

Modern climate-digital projects prioritize data mobilization and digital optimization of existing strategies. While this trend supports industrial adaptation and strengthens decision-making processes, it is not sufficient for achieving qualitative changes and climate neutrality.

Quantitative analysis indicates that the most important technologies for achieving modern climate-neutral targets are collaborative IT platforms, artificial intelligence, machine learning, and blockchain. These digital solutions are commonly used individually or in conjunction with other technologies in climate-digital projects. In contrast, satellites, sensors, drones, and remote sensing require additional support and are often utilized in combination with other IT technologies. This differentiation reflects the current demand for climate-neutral economy and its overall focus on adaptive strategies rather than development. However, in the nearest future global eco-digital projects may shift the focus into the modeling of behavior change and empowerment.

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